CONTRIBUTIONS FROM THE LABORATORY OF VERTEBRATE GENETICS

UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

NUMBER 13 MAY, 1940

INTERGRADATION BETWEEN TWO SUBSPECIES OF DEER-MOUSE (*PEROMYSCUS MANICULATUS*) ACROSS NORTH DAKOTA

BY LEE R. DICE

CONTENTS

Introduction 1
Acknowledgments 1
Methods of Study 1
Collecting Stations 2
Soil Colors 4
Variation in Dimensions of Body and Skeleton 6
Variation in Pelage Color 8
Intergraduation Between the Two Subspecies 9
Summary 13
Literature Cited 13

INTRODUCTION

IN this paper is described the intergradation between two related subspecies in an area across which the progression in environmental conditions is gradual. The locality chosen for study is the state of North Dakota. The species investigated is the deer-mouse, *Peromyscus maniculatus,* which is represented in eastern North Dakota by the subspecies *bairdii* Hoy and Kennicott and in the western part of the state by the subspecies *osgoodi* Mearns.

ACKNOWLEDGMENTS

Grateful acknowledgment is made of a grant from the Carnegie Institution of Washington to defray the field expenses incurred in the study. Assistance in measuring some of the specimens was provided by the National Youth Administration. The map was drawn by Grace Eager.

METHODS OF STUDY

The necessary breeding stocks of deer-mice for this study were collected by me in July, 1934, at short intervals along a transect from east to west across North Dakota. The first collecting station was near Valley City, the last near Dickinson. The field-caught deer-mice were shipped, soon after their capture, to the Laboratory of Vertebrate Genetics of the University of Michigan, Ann Arbor, Michigan, where they later became the parents of the mice described in the following account.

All the mice discussed in this report and listed in the tables were born in the laboratory. All were given uniform care and were fed a standard ration. In the spring of the year, at the age of approximately one year, the mice were killed, the body measurements taken before the onset of *rigor mortis,* and the skins, skulls, and femurs prepared in a standard manner for specimens. After the skulls and femurs had been properly prepared, certain measurements were taken with the aid of a micrometer operated under a low-power microscope. The color analysis of the prepared flat skins was made with an Ives tint photometer (Dice, 1932: 5–7, 19–22).

All the body measurements here discussed were made by myself. The body measurements of some additional specimens of these stocks, which by mistake were taken by another member of the staff, have been discarded. The number of mice whose body measurements are thereby excluded from consideration is of importance only in three stocks. Of the Windsor stock the body measurements of twelve individuals are for this reason omitted from the table; of the Jamestown stock, thirty-two; and of the Mandan stock, eighteen. Each of these three stocks is of good size, and the omission of these specimens has probably not greatly affected any of the means nor standard errors. All the available specimens of each stock have been employed in making the measurements of the femur and skull and in taking the tint photometer readings, except those rare specimens which are in part defective. The measurements of the femur and skull and the tint photometer readings of the flat skins were made by various assistants. The statistical calculations are by Merrel Taylor.

Statistical comparisons between the several stocks have been made according to the method of Dice and Leraas (1936). Any difference between two means which is greater than about 2.7 times its standard error is by this method considered to be significant.

COLLECTING STATIONS

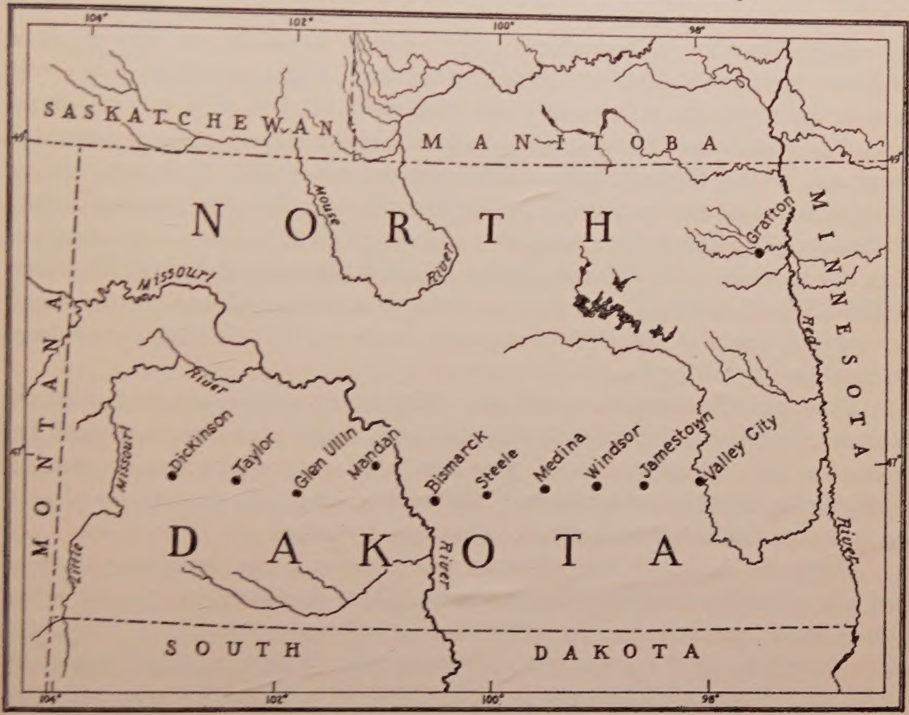
So much of North Dakota is under cultivation that in many sections it is difficult to find any remnants of the original ecologic communities. In many localities the only fairly natural habitats are within the fenced railroad right of way. These strips along the railroad are not fully natural, for, not only is the width of the habitat insufficient, but also, many situations are affected by grading operations for the railroad itself, by the construction of fire lines, and in some places by the growing of cultivated crops. Grasses of several kinds were the most important plants at all the collecting stations, but herbaceous flowering plants of numerous kinds and low shrubs were also usually present.

Breeding stocks of deer-mice were collected at the following stations (Map 1):

Valley City. In fairly natural prairie two miles north of Valley City, Barnes County, one deer-mouse was trapped, and four were taken in a very weedy grass and clover meadow near by; two others were secured in heavily pastured prairie just west of the city. All the Valley City mice were taken within an area not over two miles across, and they have been considered to be a single stock.

Jamestown. Along the railroad, seven miles east of Jamestown, in Stutsman County.

Windsor. Along the railroad, fourteen miles west of Jamestown, and two and one-half miles east of Windsor, in Stutsman County.



Map 1. The localities in North Dakota from which stocks of *Peromyscus* were collected. The black dots indicate the localities in which the respective stocks were collected, not the positions of the towns after which the stocks are named.

Medina. Along the railroad, ten miles west of Medina and sixty-nine miles west of Jamestown, in Kidder County.

Steele. Along the railroad and in an adjacent field, six miles west of Steele, Kidder County.

Bismarck. Along the railroad, nine miles east of Bismarck, in Burleigh County.

Mandan. In a grassy field adjacent to a wheat field, on rolling hills several miles from the railroad, twelve miles by road west of Mandan, in Morton County.

Glen Ullin. Along the railroad, four miles east of Glen Ullin, in Morton County.

Taylor. Along the railroad right of way, which here is in part planted to wheat, two miles west of Taylor, and about fifteen miles east of Dickinson, in Stark County.

Dickinson. Along a public road, bordering weedy fields, in hills nine miles west of Dickinson, in Stark County.

SOIL COLORS

The extreme eastern part of North Dakota is said to be covered by soils of Fargo-Bearden (Chernozem) type, which is black on the surface. Farther west and extending, along our transect, about one-third of the way across the state, the soils mostly are of Barnes-Parnell (Chernozem) type, which is said to have developed a darker surface layer than any other upland soil in the United States. The western two-thirds of North Dakota, along the line of our transect, is covered mostly by soils of Williams-Morton-Bainville (Chestnut) type, which is a dark grayish brown on the surface, but not so dark as the Barnes series (United States Soil Survey Division, 1938: 1075–77, 1083–84, and map). Areas of alluvial soil and of sand occur in various parts of North Dakota, and there are in addition many local variations in soil type.

A sample of the surface soil was taken at or near each of the several collecting stations. These soil samples were dried and later analysed for color by the tint photometer. For this purpose the instrument was adjusted to be slightly out of focus. Ten or more readings were made of each sample, the soil being well mixed before each reading.

Along the railroad right of way, where many of the collecting stations were located, the surface soil often is somewhat darkened in tone by being mixed with fine cinders. In order that no soil contaminated by these cinders should be used for analysis, all except the Windsor sample were collected at distances of one-eighth to one-half of a mile from the railroad. Care was used to take each sample from soil of the same general type as that at the station where the mice were trapped. The Windsor sample, which was taken in the trapping station, alongside the railroad tracks, has the lowest readings of all the North Dakota soil samples. The exceptionally low readings of the Windsor sample are probably in part caused by the presence of soot and fine cinders. In collecting the soil samples at some distance from the railroad, and not in the actual trapping stations, I have assumed that the inherited pelage colors of the mice have not been appreciably changed by the blackish color given to the soil alongside the railroad by the cinders, a very recent and very local feature.

The soils from eastern North Dakota average somewhat darker in color than do the soils from the western part of the state, as is shown by their lower tint-photometer readings (Table I). The progression in soil color

TABLE I

SURFACE SOIL COLOR AT NORTH DAKOTA COLLECTING STATIONS
Mean of ten tint photometer readings of each sample in per cent

Station	Red	Green	Blue-violet
Valley City	10.1	8.7	7.6
Jamestown	8.6	6.7	5.9
Windsor	7.7	6.2	5.1
Medina	14.4	11.4	9.2
Steele	11.1	8.7	7.4
Bismarck	10.2	7.6	6.1
Mandan	12.7	10.6	8.5
Glen Ullin	14.4	10.9	8.3
Taylor	11.9	8.7	6.4
Dickinson	12.7	9.2	6.8

across the state is, however, not very uniform. The Medina station, in particular, has soil which is paler in color than is the soil of the other eastern stations, and paler also than is that of most of the western stations. The reading for red of the Medina soil equals that of the Glen Ullin soil, and in readings for green and blue-violet the Medina soil averages the highest of all. This confirms the field observation that the Medina location had very pale soil.

The North Dakota stations having the palest surface soils are Medina, Glen Ullin, Mandan, and Dickinson. All these except the Medina station are located west of the Missouri River. The Dickinson soil sample is, however, exceeded in tint photometer readings for blue-violet by the soils from Valley City and from Steele. The soil of the Taylor station, which also is west of the Missouri River, ranks intermediate among the North Dakota stocks in shade of color.

The darkest soil samples are those from Windsor, Jamestown, and Bismarck. All these stations are located east of the Missouri River, though the Bismarck station is only a few miles from the river. The Valley City soil sample, however, has a lower reading for red than has the Bismarck sample.

The stations which are intermediate in shade of soil color are those from Taylor, Steele, and Valley City. Taylor is in the western part of the state, and Valley City is near the eastern border. The Valley City soil sample has a somewhat unusual position among the other samples, for it ranks rather low in readings for red, but rather high in readings for blue-violet.

None of the western North Dakota soils are nearly as pale as are the soils of some of the desert parts of southwestern North America. The palest of the western Dakota soils has a tint photometer reading for red of only 14.4 per cent, whereas many of the soils of the more arid parts of Arizona have readings of over 30 per cent (Dice and Blossom, 1937: 101, Table 8).

It is evident, therefore, that although the soils from the western part of North Dakota are in general paler than those of the eastern part, the difference in shade of color between the surface soils from the two ends of the state is not very great. Furthermore, the transition from the eastern dark-colored soils to the western paler soils is not an even gradation, but there is much local variation in soil color.

VARIATION IN DIMENSIONS OF BODY AND SKELETON

In the comparison of particular measurements in the several stocks, any measurement of which the means are not significantly smaller than the highest mean of the group are regarded as large in that dimension; any measurement of which the means do not significantly exceed the lowest mean are considered small; and any measurement of which the means are both significantly lower than the highest mean and significantly higher than the lowest mean are given as intermediate.

TABLE II

MEASUREMENTS OF *PEROMYSCUS MANICULATUS* FROM NORTH DAKOTA
Means and standard errors for 1-year age class, both sexes, in millimeters

Stock	No.	Mean Age, in Weeks	No. of Parents	Body Length	Tail Length	Foot Length	Ear Length
Valley City	99	56	6	96.44 ± .51	56.22 ± .44	19.215 ± .058	15.405 ± .061
Jamestown	106	51	15	95.51 ± .37	58.70 ± .39	18.901 ± .068	15.268 ± .054
Windsor ...	113	53	14	92.85 ± .31	58.18 ± .38	18.658 ± .061	15.383 ± .053
Medina	89	49	5	92.31 ± .43	58.17 ± .37	19.381 ± .071	15.067 ± .052
Steele	138	58	9	93.73 ± .35	57.71 ± .40	18.948 ± .048	15.614 ± .054
Bismarck ...	81	53	11	95.08 ± .39	60.64 ± .45	19.124 ± .071	15.408 ± .069
Mandan	96	55	12	95.72 ± .41	63.78 ± .49	19.644 ± .061	15.996 ± .065
Glen Ullin	81	54	5	97.09 ± .38	62.56 ± .45	19.259 ± .061	16.416 ± .076
Taylor	82	55	9	96.67 ± .44	60.72 ± .46	19.326 ± .056	16.040 ± .060
Dickinson...	36	56	4	97.00 ± .63	58.50 ± .53	19.856 ± .087	16.106 ± .110

Stock	Left Femur	Left Mandible	Condyle-premaxilla	Condyle-zygoma	Bullar Width
Valley City ...	15.720 ± .053	15.838 ± .043	23.911 ± .064	17.165 ± .045	10.710 ± .026
Jamestown	15.460 ± .066	15.778 ± .038	23.508 ± .051	17.066 ± .042	10.718 ± .031
Windsor	15.965 ± .068	15.768 ± .043	23.336 ± .055	16.886 ± .040	10.627 ± .025
Medina	15.781 ± .060	15.600 ± .040	23.390 ± .074	16.812 ± .050	10.537 ± .030
Steele	15.761 ± .055	15.485 ± .044	23.456 ± .064	17.081 ± .041	10.580 ± .018
Bismarck	15.588 ± .063	15.549 ± .049	23.408 ± .060	17.094 ± .050	10.545 ± .032
Mandan	15.890 ± .061	15.849 ± .065	23.861 ± .065	17.183 ± .048	10.759 ± .029
Glen Ullin	16.271 ± .065	16.396 ± .042	24.214 ± .066	17.489 ± .052	10.839 ± .029
Taylor	16.171 ± .058	16.169 ± .048	24.386 ± .060	17.649 ± .048	10.874 ± .030
Dickinson	16.549 ± .102	15.949 ± .071	23.942 ± .068	17.436 ± .059	10.746 ± .045

The stocks from the more eastern North Dakota localities—Valley City, Windsor, Jamestown, Medina, Steele, and Bismarck—tend to be small in their dimensions (Table II). The most easterly stock, however, that from Valley City, does not quite harmonize with the others, for it ranks small in tail length, large in body length, and intermediate in all the other measurements. The Windsor stock ranks small in body length, foot length, condylopremaxillary skull length, condylo-zygomatic distance, and bullar width of skull, and intermediate in its other dimensions. The Jamestown stock ranks small in foot length, ear length, femur length, and condylo-premaxillary skull length, and intermediate in the other measurements. The Medina stock ranks small in all measurements except tail length, foot length, and femur length, in which measurements it is intermediate. The Steele stock ranks small in body length, tail length, length of mandible, condylo-premaxillary skull length, and bullar width of skull, and is intermediate in the others. The Bismarck stock ranks small in femur length, length of mandible, condylo-premaxillary skull length, and bullar width of skull, and is intermediate in the other measurements.

Thus all the stocks from east of the Missouri River rank small or intermediate among the North Dakota stocks, except that the Valley City stock ranks large in body length.

Likewise, the North Dakota stocks from west of the Missouri River, taken at Mandan, Glen Ullin, Taylor, and Dickinson, have an evident tendency to be larger than those from the stations farther east. The Dickinson stock, which is from a locality farther west than the localities of the other stocks here described, ranks large in body length, hind-foot length, ear length, femur length, and condylo-zygomatic distance, and is intermediate in all the other measurements. The Taylor stock ranks large in body length, condylo-premaxillary skull length, condylo-zygomatic distance, and bullar width of skull, and is intermediate in the other measurements. The Glen Ullin stock significantly exceeds all the others in length of mandible, and ranks large in all the other measurements except foot length, in which it is intermediate. The Mandan stock ranks large in body length, tail length, and foot length and is intermediate in the other measurements. In no measurement do the Dickinson, Taylor, Glen Ullin, or Mandan stocks rank small among the North Dakota stocks.

It appears that, with one exception, none of the North Dakota stocks from east of the Missouri River ranks large in any measurement, and neither does any stock from west of the river rank small in any measurement.

Notwithstanding the differences in dimensions between the North Dakota stocks east of the Missouri River from those west of the river, there is much overlapping in measurements between the two groups of stocks. Only for ear length do all the stocks west of the river significantly exceed those east of the river. The smallest-eared stock west of the Missouri River (Mandan) exceeds in ear length the largest-eared stock east of the river (Steele) by 0.382 ± .085 mm. This difference, while important statistically, is not very great in actual amount. The greatest difference in ear length between any of the stocks here described is 1.349 ± .092 mm., between the Glen Ullin and Medina stocks. Even this amount of difference in ear length is not very evident in the live animals.

There is much variation in the rank of the several stocks for the individual measurements. A stock which ranks moderately large in one measurement may rank small in other dimensions. Frequently an eastern stock will significantly exceed, in a particular measurement, a number of stocks from localities considerably farther west. This tendency toward local variability may be illustrated by the fact that the Valley City stock significantly exceeds the Jamestown stock in foot length, femur length, and condylo-premaxillary skull length, but is significantly smaller than the Jamestown stock in tail length.

Although the western North Dakota stocks tend to average larger than the eastern stocks in all dimensions of the body and skeleton, there is no sharp dividing line anywhere between the eastern and western Dakota stocks. Neither do these stocks form an evenly graded series from east to west. On the contrary, the east-to-west increase in the size of the deer-mouse across North Dakota proceeds very irregularly, and is in many places interrupted by local variations.

VARIATION IN PELAGE COLOR

The pelage color of the North Dakota stocks of deer-mice here described tends to be darkest in those from the more eastern localities. The Valley City stock, which comes from the most easterly locality, has significantly lower tint photometer readings of the dorsal stripe and of the amount of green reflected from the side of the body than has any other Dakota stock (Table III). The Jamestown stock also ranks relatively low in tint photometer readings, though it has significantly higher readings through most color screens than has the Valley City stock. The Windsor and Bismarck stocks rank fairly low in pelage color, but in many color comparisons the tint photometer readings of one or both of these stocks significantly exceed the readings of both the Jamestown and the Valley City stocks.

The tendency for the more easterly of the North Dakota stocks to be dark in pelage is definitely not followed by the Medina stock, which comes from a location not far west of Jamestown. The Medina stock, on the contrary, is the palest in pelage of all the North Dakota stocks. Its mean tint photometer readings, both of the dorsal stripe and of the side of the body, are not exceeded by those of any other North Dakota stock.

The two most westerly stocks, Dickinson and Taylor, are, except for the Medina stock, the palest in pelage of all the North Dakota stocks. The Dickinson and Taylor stocks are significantly exceeded in tint photometer readings only by the Medina stock, and then only for the readings of green and of blue-violet reflected from the dorsal stripe.

The Windsor, Bismarck, Steele, Glen Ullin, and Mandan stocks are of intermediate shade of pelage, with, in general, the Windsor and Bismarck stocks ranking fairly dark and the Mandan stock fairly pale for this intermediate group. It may be noted that the Glen Ullin stock, which comes from a locality west of Mandan, has lower mean tint photometer readings

TABLE III

PELAGE COLOR OF *PEROMYSCUS MANICULATUS* FROM NORTH DAKOTA
Mean tint photometer readings and standard errors, 1-year age class, both sexes, in per cent

Stock	Dorsal Stripe		
	Red	Green	Blue-violet
Valley City	5.61 ± .12	4.29 ± .09	3.36 ± .08
Jamestown	6.59 ± .13	5.08 ± .10	3.87 ± .08
Windsor	7.22 ± .13	5.18 ± .09	3.67 ± .07
Medina	9.70 ± .10	7.64 ± .09	5.86 ± .07
Steele	8.45 ± .14	6.17 ± .11	4.56 ± .09
Bismarck	7.58 ± .14	5.43 ± .09	4.06 ± .07
Mandan	8.81 ± .14	6.37 ± .10	4.56 ± .08
Glen Ullin	8.03 ± .14	6.13 ± .12	4.52 ± .09
Taylor	9.77 ± .19	7.10 ± .14	5.37 ± .10
Dickinson	9.08 ± .22	6.78 ± .16	5.08 ± .11
Stock	Side		
	Red	Green	Blue-violet
Valley City	14.15 ± .22	10.14 ± .14	7.49 ± .11
Jamestown	14.76 ± .19	10.75 ± .13	7.93 ± .13
Windsor	16.74 ± .23	11.57 ± .18	8.10 ± .13
Medina	19.71 ± .21	14.59 ± .17	10.77 ± .12
Steele	17.19 ± .23	12.03 ± .14	8.61 ± .11
Bismarck	16.44 ± .23	11.54 ± .17	8.23 ± .12
Mandan	19.31 ± .23	13.69 ± .18	9.61 ± .13
Glen Ullin	17.51 ± .23	12.64 ± .19	9.27 ± .15
Taylor	19.23 ± .27	13.87 ± .19	9.99 ± .14
Dickinson	18.89 ± .38	14.06 ± .34	10.31 ± .20

than has the Mandan stock, and that in some color comparisons the differences are statistically significant.

Although the pelage of most of the eastern stocks of deer-mice in North Dakota is dark whereas that of most of the western stocks is pale, the sequence of stocks arranged according to mean tint photometer readings does not closely follow the geographical order of the collecting stations. In other words, there is much local variation in pelage color. In particular, the Medina stock, which comes from the eastern part of the state and might accordingly be expected to be fairly dark in color, actually is the palest in pelage color of all the North Dakota stocks.

INTERGRADATION BETWEEN THE TWO SUBSPECIES

Gently rolling plains cover most of North Dakota, and there is no abrupt change in topography anywhere along the transect where the breeding stocks of mice for this study were collected. The Missouri River and the few other smaller streams of the area lie in shallow valleys, which are not much lower than the general level of the plains. Farther west, along the Little Missouri River, extensive badlands have been developed by erosion, and there the topography and soils are considerably different from the topography and soils along the transect here described. It was for this reason that the transect was not carried west beyond the Dickinson station.

In spite of the general similarity of the topography over most of North Dakota, there is a gradual increase in altitude between the eastern and the western part of the state. The city of Grafton lies at an altitude of 827 feet above sea level, but the town of Dickinson is at 2543 feet.

There is also a gradual east-to-west progression in climate in North Dakota, for the eastern part of the state receives a somewhat greater amount of precipitation than does the western part. According to data published by the United States Weather Bureau, Grafton, Valley City, and Jamestown in eastern North Dakota have an annual precipitation of between eighteen and twenty inches, and Dickinson, Glen Ullin, and Mandan, in the western part of the state, average between fifteen and sixteen inches.

Associated with the difference in climate between the eastern and western parts of the state, western North Dakota has a somewhat more arid type of vegetation than eastern Dakota. The climax vegetation of western North Dakota is mixed prairie, dominated by a mixture of short and mid-grasses. In the eastern part of the state the climax is true prairie, in which the short grasses are lacking (Clements and Shelford, 1939: 260–77).

That the deer-mouse environment changes gradually and evenly from east to west in North Dakota must not, however, be assumed. The surface soils are in general somewhat paler in western than in eastern North Dakota, but, as shown in an earlier section of this report, these soils exhibit much local variation in shade of color from place to place. The native vegetation of the state is now largely destroyed, but it may safely be inferred that, correlated with the local variations in soil and in topography, there has always been also considerable local variation in the vegetation.

Of the two subspecies of deer-mice in North Dakota, *bairdii* is characterized by small body, short tail, small ear, and by dark pelage. The subspecies *osgoodi* is somewhat larger than *bairdii* in body length, has a longer tail and a considerably larger ear, and is paler in pelage (Osgood, 1909: 75–80). Intergradation between the two subspecies occurs, according to Bailey (1926: 73–76), mainly east of the Missouri River, at about the one-hundredth meridian.

The Valley City stock and also the previously described Grafton stock may be assumed to be more or less typical of the subspecies *bairdii*. The measurements of hind-foot length of both the Valley City and Grafton stocks significantly exceed those of all the stocks from more eastern states (Dice, 1937), though they do not differ significantly from those of the Onaga, Kansas, stock. In femur length, condylo-premaxillary skull length, and bullar width of skull the Valley City stock significantly exceeds all the stocks from more eastern states, but the Grafton stock does not. In none of the other measurements are there significant differences between the two most easternly North Dakota stocks and the stocks from Minnesota, Iowa, Illinois, and Michigan.

In tint photometer readings of pelage color the Grafton and Valley City stocks significantly exceed some of the stocks from states farther east, but neither of them significantly exceeds the Sand Point, Michigan, stock for any color screen. It seems safe, therefore, to consider the Grafton and Valley City stocks from eastern North Dakota as at least fairly typical of the subspecies *bairdii.*

It is not so certain that the deer-mice of western North Dakota are typical of the subspecies *osgoodi.* Compared to the stocks of *osgoodi* described by Leraas (1938: 3–12) from the Uinta Mountains of Utah, the three most western stocks from North Dakota (Dickinson, Taylor, and Glen Ullin) are all significantly larger in body length, but significantly shorter in tail length, hind-foot length, and ear length. In the measurements of the femur and skull there are, on the contrary, no significant differences between the western North Dakota and the Utah *osgoodi.* In tint photometer readings of pelage color the Utah *osgoodi* significantly exceed most of the North Dakota stocks. In the readings of green and blue-violet reflected from the side of the body, however, the Sheep Creek, Utah, stock does not differ significantly from either the Medina or Dickinson stocks.

No comparable measurements of *osgoodi* from parts of its range other than the Uinta Mountains are yet available. The *osgoodi* described by Adolph Murie (1933: 6–11) from Glacier Park, Montana, were not born in the laboratory, and are accordingly not comparable with the laboratory-bred Dakota mice. If the Utah stocks do indicate the characters of *osgoodi,* then none of the western North Dakota stocks are fully typical of the subspecies, for all of these Dakota stocks have greater body length, but are shorter in tail length, foot length, and ear length, and darker in pelage color than are the Utah stocks.

There is some further question about the typical character of the western North Dakota *osgoodi,* because Osgood (1909: 77–79) referred specimens from Dickinson to the subspecies *luteus* (=*nebrascensis*), a very pale, buff-colored, short-eared subspecies found mostly in the Nebraska sand hills. Osgood also stated that some specimens from Glen Ullin approach *luteus.* The reference of these North Dakota specimens to *luteus* probably indicates that near these localities in western North Dakota there are local races with exceptionally pale pelage colors. The stocks here described from Dickinson and Glen Ullin, however, have lower average tint photometer readings (and accordingly are darker in shade of pelage color) than are some others of the stocks from western North Dakota. This probably only means that the specimens listed by Osgood came from different local situations than the stocks here described under the same geographic names.

Whether or not the western North Dakota stocks of *osgoodi* are typical of the subspecies, they were demonstrated earlier in this report to be paler in pelage, on the average, than are the two eastern stocks from Grafton and Valley City, which represent the subspecies *bairdii.* Furthermore, the western North Dakota stocks tend to average larger than the eastern stocks in all dimensions of the body and skeleton.

Between the *bairdii* of eastern North Dakota and the *osgoodi* of the western part of the state there is a wide belt of intergradation, and any line which might be drawn to separate the two subspecies would have to be drawn in a very arbitrary manner. For instance, the Medina stock, which comes from toward the eastern part of the state, has pelage generally paler than that of any of the western North Dakota stocks. Further, the Valley City stock assigned to *bairdii* does not differ significantly from the Dickinson stock in body length, foot length, mandibular length, condylo-premaxillary skull length, nor bullar width of skull.

In the wide area of intergradation between *bairdii* and *osgoodi,* which includes much of middle North Dakota and possibly may extend west beyond the western border of the state, there is, then, a very considerable amount of local variation. This variability often obscures, and sometimes locally reverses, the geographic trend in these deer-mice toward paler colors and larger size to the westward.

That the soils of western North Dakota tend to be paler in color than those of the eastern part of the state has been demonstrated in an earlier section of this paper. There is a possibility, therefore, that the pale colors of the western Dakota stocks, as compared to the stocks from the eastern part of the state, indicate some direct or indirect relationship between pelage color and soil color. Such a trend toward correlation between pelage color and soil color has previously been noted in other regions (Dice and Blossom, 1937: 92–108). Possibly in conformance to such a trend, the Medina stock, which is pale for its geographical situation toward the eastern part of the state, comes from a local area of very pale soil. Likewise, the Jamestown and Windsor stocks, which come from areas of dark-colored soil, are fairly dark in pelage and rank next above the Valley City stock, which has the darkest-colored pelage of all the North Dakota deer-mice. Accordingly, there seems to be a general tendency for these North Dakota deer-mice to vary in pelage color in correlation with the color of the surface soil of their habitat.

There are many exceptions, however, to the general trend toward a correlation between pelage color and soil color. For instance, the Glen Ullin soil ranks among the palest in color tone of the North Dakota soil samples, but the Glen Ullin mice rank intermediate among the other stocks in pelage color. Likewise, the Valley City soil sample ranks generally intermediate among the other soils in shade of color, but the Valley City mice have the lowest tint photometer readings of all the North Dakota stocks. It seems necessary to conclude that, although there is a general tendency for the shade of pelage color of the deer-mice to vary in the same direction as the shade of color of the soil, this tendency frequently is obscured or reversed by the existence of the numerous local races.

Pelage color seems to be the only character of these deer-mice which shows any tendency toward correlation with any environmental feature. So far as can be detected, none of the variations in the dimensions of the body or skeleton of these mice are correlated in any way with the character of the habitat.

SUMMARY

There is a broad area of intergradation across North Dakota between the small, dark-colored, eastern subspecies, *Peromyscus maniculatus bairdii,* and the larger, paler-colored, western subspecies *osgoodi.* The transformation of the characters of *bairdii* to those of *osgoodi* is correlated with the increase in elevation, with the decrease in the amount of precipitation, with the more arid character of the vegetation, and with the increasing paleness of the surface soil from east to west in North Dakota. The intergradation between *bairdii* and *osgoodi* which occurs in North Dakota is, however, not a gradual, progressive change from one form to the other. On the contrary, the transition between the two forms often is obscured or locally reversed by the general occurrence of local races which depart more or less from the expected gradient of change.

There is a tendency for the pelage colors of the local races of these mice in North Dakota to vary in correlation with the colors of the surface soils of their habitats, but none of the other characters of these animals seems to have any obvious correlation with any feature of the environment.

LITERATURE CITED

BAILEY, VERNON

1926 A biological survey of North Dakota: I, Physiography and life zones; II, The mammals. U. S. Bur. Biol. Surv., N. Amer. Fauna, No. 49: i–vi + 1–226, 21 pls., 8 figs.

CLEMENTS, FREDERIC E., AND VICTOR E. SHELFORD

1939 Bio-ecology. New York: John Wiley and Sons. vii + 425 pp., 85 figs.

DICE, LEE R.

1932 Variation in a geographic race of the deer-mouse, *Peromyscus maniculatus bairdii.* Occ. Papers Mus. Zool. Univ. Mich., No. 239: 1–26, 1 fig.

1937 Additional data on variation in the prairie deer-mouse *Peromyscus maniculatus bairdii. Ibid.,* No. 351: 1–19, 1 map, 2 figs.

DICE, LEE R., AND PHILIP M. BLOSSOM

1937 Studies of mammalian ecology in southwestern North America, with special attention to the colors of desert mammals. Carnegie Inst. Wash. Publ., 485: iv + 129 pp., 8 pls., 8 figs.

DICE, LEE R., AND HAROLD J. LERAAS

1936 A graphic method for comparing several sets of measurements. Contrib. Lab. Vert. Gen. Univ. Mich., No. 3: 1–3, 1 fig.

LERAAS, HAROLD J.

1938 Variation in *Peromyscus maniculatus osgoodi* from the Uinta Mountains, Utah. Contrib. Lab. Vert. Gen. Univ. Mich. No. 6: 1–13, 2 figs.

MURIE, ADOLPH

1933 The ecological relationship of two subspecies of *Peromyscus* in the Glacier Park region, Montana. Occ. Papers Mus. Zool. Univ. Mich., No. 270: 1–17, 2 figs.

OSGOOD, WILFRED H.

1909 Revision of the mice of the American genus *Peromyscus.* U. S. Bur. Biol. Surv., N. Amer. Fauna, No. 28: 1–285, 8 pls., 12 figs.

UNITED STATES SOIL SURVEY DIVISION

1938 Soils of the United States. Yearbook U. S. Dept. Agric. 1938: 1019–1161, 57 figs., 1 colored map.